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LIVING BEHAVIOUR ASSESSMENT AT RESIDENTIAL COLLEGE BUILDING WITH BIOCLIMATIC DESIGN STRATEGIES

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ABSTRACT

The assessment through field measurement with the use of climatic devices and survey by using a set of questionnaire was conducted in a residential college building with the best practice of bioclimatic design strategies. The recorded values of indoor climate are in the range of 29-30°C of the mean temperature with 72-77% of relative humidity. The comfort level was successfully maintained with a good adaptation of living behaviour including the activity in the room, garment dressed, and usage of room opening, curtains and ceiling fan.

Keyword: bioclimatic design; comfort; living behaviour; residential college.

INTRODUCTION

Bioclimatic design strategies integrate the disciplines of human physiology, climatology and building physics (Olgyay, 1963). These strategies help to eliminate negative environmental impact completely through skilful and sensitive designs that encourage the better use of building resources and significant operational savings (Yeang, 2008). The Dayasari Residential College (Dayasari RC) has been acknowledged as the residential college building in University of Malaya (UM) campus with the best practice of bioclimatic design strategies, particularly daylighting and natural ventilation (Jamaludin et al., 2013; In press). As consequences, Dayasari RC has to be among the buildings with the lowest Energy Efficiency Index (34.52 kWh/m^2/year) compared to the other residential colleges; which are in the range of 40 to 125 kWh/m^2/year (Jamaludin et al., 2013).

The aim of this study is to evaluate the condition of the building by focusing on the temperature and relative humidity with the purpose of justifying the effectiveness of applying bioclimatic design strategies for residential colleges. Concurrently, determine the residential living behaviour in adapting to the recent environment to achieve a state of comfort in the room. Residents' adjusting behaviours would serve as concrete and effective information to improve indoor comfort levels (Tae et al., 2012).

EXPERIMENTAL PROCEDURE

The field measurement was only done for two weeks at selected occupied rooms as permitted by the residential college administrators. These rooms are decidedly the most excellent rooms to represent ten scenarios which concern the level of radiation and penetration of sunlight into the rooms (Yeang, 2008); that theoretically represent the condition of the whole building. The ten identified scenarios are; north, east, south and west orientation, avoiding direct contact with man-made surfaces on the top and on the ground, direct contact with man-made surfaces on the top and on the ground, shaded and exposed.

One ONSET HOBO U12-012 data logger for indoor climate measurements was fixed on the centre of the room and outside the selected student rooms, specifically at the corridor area at the height of 1.10m above the floor; the typical human body level (Nugroho et al., 2007). Two parameters collected; air temperature (°C) and relative humidity (%). This microclimatic measurement set was to cover a 24-hour period with one-hour intervals between measurements (Dahlan et al., 2009). The data on the microclimate were taken from the UM weather station.

Concurrently, all the residents in all selected rooms were asked to record the overall comfort level of their rooms, the usage of electronic devices and room opening, activity in the room and garment dressed for three times a day during the course of the research. Each time a day is assigned to different periods which are morning (6 a.m. - 12 p.m.), afternoon (12 p.m. - 6 p.m.) and evening (6 p.m. - 12 a.m.); as the occupants need to attend lectures at their faculty and attend their own off-campus activities. Thus, the residents were able to give their responses in a long time frame while avoiding them from losing their attention and getting apathetic. The statistical computer software package was used for further comprehensive analysis.

RESULT AND DISCUSSION

The mean values of the climate's condition that includes the indoor, corridor and microclimate during three different time periods are statistically presented in Table 1. The microclimate has a better condition as compared to the corridor climate and the corridor climate was better than the indoor climate in terms of the lowest mean temperature with the highest mean percentage of relative humidity. The temperature was drastically increased in the afternoon and slightly decreased in the evening. The indoor mean temperature in the evening was maintained as in the afternoon with a small increment of relative humidity percentage; which was about 2%. In the corridor and the microclimate, the percentage of relative humidity had considerably increased with the reduction of the temperature values; in the range of 8 to 14%. The largest amount of total rain was recorded in the evening which influenced the percentage of relative humidity especially in the microclimate.

TABLE 1 The mean values of the climate’s condition

Climate	Parameter	Time		
		Morning	Afternoon	Evening
Indoor	Temperature (°C)	29 (25-31)*	30 (26-34)*	30 (26-33)*
	Relative humidity (%)	77 (61-90)*	72 (54-88)*	74 (57-90)*
Corridor	Temperature (°C)	28 (24-32)*	30 (25-35)*	29 (25-34)*
	Relative humidity (%)	81 (61-94)*	69 (48-93)*	77 (50-94)*
Microclimate	Temperature (°C)	27 (25-30)*	30 (26-33)*	28 (24-31)*
	Relative humidity (%)	84 (62-95)*	67 (56-90)*	81 (59-95)*
	Total rain amount (mm)	0 mm	6.1 mm	45.4 mm
Note:	* Minimum and maximum value			

The usage of room opening and electronic devices, activity in the room, garment dressed by the residents, and overall comfort level according to different time periods are all presented in Table 2. The basic electrical appliances in the room such as ceiling fan, ceiling lamp, study lamp and computer were fully utilised in the evening when the room happened to be fully occupied. Hence, there were internal thermal loads produced by people and electrical appliances (Ghisi & Massignani, 2005). This explains the retaining of high temperature in the room while the temperature in the corridor and the microclimate was drastically reduced after 6 p.m. (Table 1), besides the effects of building thermal mass when the building acts as a heat sink; absorbing the heat gains during the day and releasing heat in the night time.

The residents were well adapted with the significant increase of temperature in the afternoon, which was up to 3°C. The ceiling fan has been used at full speed at all times by the majority of the residents to maintain the air circulation in the room when the windows had been closed most of the time. The curtains were fully utilised in the afternoon by half of the residents to control the amount of daylight into the room to reduce the glare and the heat caused by the daylight penetration (Omer, 2008). In fulfilling the needs for privacy and protection from various external effects, the curtains had been overused; especially for those who are living on the ground floor or facing the adjacent residential block occupied by students of opposite gender (Jamaludin et al., in press).

The majority of the residents only did a light activity, which was seated in a relaxed mode (1.0 Met) to reduce the metabolic heat production. Light clothes with the cloth insulation value in the range of 0.06 to 1.03 clo; with the mean value up to 0.20 clo, were worn at most times. Higher mean value of clo was recorded in the afternoon when most of the residents were dressed with proper apparel for the classes at the faculties. This value is much lower than the suitable cloth insulation value of tropical clothing; 0.55 clo (Nughoro et al., 2007). With the well adaptation through the changes of living behaviour, the majority of the residents of residential college building with the best practice of bioclimatic design strategies felt ‘neutral’ of overall comfort level with regards to the three different time periods.

TABLE 2 The usage of room opening and electronic devices, activity in the room, garment dressed by the residents, and overall comfort level

The performance indicator		Time & Percentages of usage			Overall
		Morning	Afternoon	Evening	%
Ceiling fan	On	98.8	96.7	99.5	96.7
	Off	1.2	9.3	0.5	3.3
Ceiling fan speed	0	1.2	8.6	0.6	3.1
	1	0.0	0.6	0.0	0.3
	2	3.5	2.0	2.6	2.7
	3	30.2	6.0	8.9	11.8
	4	15.0	12.6	18.8	15.7
	5	60.1	70.2	69.1	66.4
Ceiling lamp	On	20.8	21.9	90.1	46.8
	Off	79.2	78.1	9.9	53.2
Study lamp	On	15.7	16.6	71.7	36.8
	Off	84.3	83.4	28.3	63.2
Computer	On	42.4	43.7	71.7	53.7
	Off	57.6	56.3	28.3	46.3
Phone charger	On	18.0	22.5	46.8	30.0
	Off	82.0	77.5	53.2	70.0
Windows	Open	18.0	26.5	42.0	29.6
	Close	82.0	73.5	58.0	70.4
Curtain	Open	50.6	49.3	64.4	55.4
	Close	49.4	50.7	35.6	44.6
Activity	Reclining (0.8 Met)	17.2	4.1	3.7	8.3
	Seating relaxing (1.0 Met)	59.3	70.7	65.9	65.0
	Sedentary activity (1.2 Met)	20.7	21.1	27.4	23.4
	Standing relaxed (1.2 Met)	0.0	0.0	0.6	0.3
	Domestic work (1.7 Met)	2.1	2.4	1.8	2.1
	Walking on 5 km (3.4 Met)	0.7	1.7	0.6	0.9
Garment dressed	Mean value (clo)	0.18 (0.06-1.03)*	0.20 (0.06-1.03)*	0.19 (0.06-0.83)*	0.19 (0.06-1.03)*
Overall comfort level	Very uncomfortable	0.0	0.7	0.5	0.5
	Uncomfortable	6.4	15.2	6.8	9.1
	Neutral	50.9	49.7	47.4	49.2
	Comfortable	41.6	33.1	41.7	39.1
	Very comfortable	1.1	1.3	3.6	2.1

Note: * Minimum and maximum value

CONCLUSION

The implementation of bioclimatic design strategies, particularly daylighting and natural ventilation for residential colleges has a positive impact on overall comfort level of the residents. The recorded values of indoor climate are; 29-30°C of the mean temperature with 72-77% of relative humidity.

The comfort level of the room was successfully maintained with a good adaptation through the changes of living behaviour such as; only did light activity - seated in a relaxed mode (1.0 Met), worn light clothes (0.06 to 1.03 clo with the mean value up to 0.20 clo), used ceiling fan at full speed at all times and fully utilised the curtains especially in the afternoon..

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